

Application Serial No. 10/517943
Amendment and Response
Office Action dated 10/05/2006

Amendments to the Specification

Amendment to the Abstract:

A chip resistor includes a resistor element of a rectangular solid made of an alloy composed of high-resistant metal and low-resistant metal, ~~while also including~~ The resistor has connection terminal electrodes disposed at the ends of the resistor element that are spaced longitudinally of the rectangular solid. The resistance of the chip resistor is ~~expected to be~~ lowered without incurring an increase in the temperature coefficient of resistance and the weight. A plating layer is formed on the resistor element, where the plating element is made of pure metal having a lower resistance than that of the alloy constituting the resistor element.

~~The above object is attained by forming a plating layer on the resistor element, where the plating layer is made of pure metal having a lower resistance than that of the alloy constituting the resistor element.~~

Application Serial No. 10/517943
Amendment and Response
Office Action dated 10/05/2006

Amendments to the Specification

Please amend the section entitled Disclosure of the Invention on page 4 line 11 through page 12, line 14 as follows:

DISCLOSURE OF THE INVENTION SUMMARY

~~An object of the present invention is to provide a chip resistor for solving the above problem, and a method of making the same.~~

~~In order to achieve the above object, according to claim 1, a~~ A chip resistor having low resistance ~~of the present invention~~ comprises a resistor element formed an alloy of high-resistant metal and low-resistant metal into a rectangular solid, and connection terminal electrodes formed at ends of the resistor element. The resistor element has a surface formed with a plating layer ~~which is made of pure metal with resistance lower than the resistance of the alloy making the resistor element. According to claim 2, the~~ The alloy making the resistor element has a negative temperature coefficient of resistance. ~~According to claims 3 and 4, the~~ The resistor element is formed with a sectional area reducing portion ~~which is filled with the plating layer. According to claim 5, the~~ The plating layer on the surface of the resistor element is divided between the connection terminal electrodes, or is narrowed at least partially between the connection terminal electrodes. ~~According to claims 6 and 7, the~~ The connection terminal electrodes are integrally extended from ends of the resistor element toward a lower surface of the resistor element. The plating layer is extended into a surface of the extended electrodes. ~~According to claims 8 and 9, The~~ metal plates serving as connection terminal electrodes are fixed to ends of the lower surface of the resistor element. An insulator covers an upper surface of the resistor element formed with the plating layer, while also covering a portion between the connection terminal electrodes on the lower surface of the resistor element. ~~According to claims 10 and 11, at~~ At least the lower surface of the resistor element except for ends thereof is covered by an insulator. The lower surface of the resistor element is formed with a metal plating layer disposed at the ends non-covered by

Application Serial No. 10/517943
Amendment and Response
Office Action dated 10/05/2006

the insulator. The metal layers serve as the connection terminal electrode of the resistor element. ~~According to claims 12 and 13, the~~ The metal layers formed at the ends of the lower surface have a thickness equal to or larger than a thickness of the insulator covering the lower surface of the resistor element. ~~According to claims 14 and 15, the~~ The upper surface and right and left side surfaces of the resistor element are covered by an insulator.

~~According to claim 16,~~ Also disclosed is a method of making a chip resistor having low resistance ~~comprises~~ comprising the steps of: preparing a lead frame integrally formed with a plurality of lead bars for forming resistor elements, the preparation using an alloy plate of high-resistant ~~resistance~~ metal and low-resistant ~~resistance~~ metal; forming a pure metal plating layer on a surface of the resistor element in each bar of the lead frame; adjusting the resistance of the resistor element in each bar of the lead frame; and cutting the resistor element in each bar off the lead frame after an insulator for covering the resistor element is formed.

~~According to claim 17,~~ Further disclosure is of a method of making a chip resistor having low resistance comprises the steps of: preparing a laminated metal material by fixing a resistor element alloy plate and a connection terminal electrode metal plate to each other, the alloy plate being made of an alloy composed of high-resistant ~~resistance~~ metal and low-resistant ~~resistance~~ metal and being formed integrally with a plurality of resistor elements of a rectangular solid arranged, the connection terminal metal plate being made of a metal having resistance lower than the alloy plate; removing portions of the connection terminal electrode metal plate so as to leave connection terminal electrodes after a plating layer of pure metal is formed on an upper surface of the resistor element alloy plate in the laminated material metal plate, or forming a plating layer of pure metal on an upper surface of the resistor element alloy plate after portions of the connection terminal electrode metal plate in the laminated material metal plate are removed so as to leave connection terminal electrodes; forming insulators for covering the upper surface of the alloy plate and a part of the lower surface of the connection terminal electrode metal plate other than the connection terminal electrodes; and cutting the laminated material metal plate into the resistor elements.

Application Serial No. 10/517943
Amendment and Response
Office Action dated 10/05/2006

~~According to claim 18,~~ a A method of making a chip resistor having low resistance comprises the steps of: making a rectangular resistor element from a metal plate; forming a pure metal plating layer on a surface of the resistor element; forming an insulator for covering at least a lower surface of the resistor element at a portion other than ends thereof; and forming metal plating layers serving as connection terminal electrodes of the resistor element at the ends of the lower surface of the resistor element which are non-covered by the insulator.

~~According to claim 19,~~ a A method of making a chip resistor having low resistance comprises the steps of: making a rectangular resistor element from a metal plate, forming a pure metal plating layer on a surface of the resistor element; forming insulators for covering an upper surface; a lower surface, and right and left side surfaces of the resistor element except for the ends of the lower surface; and forming metal plating layer for serving as connection terminal electrodes of the resistor element at the ends of the lower surface of the resistor element which are non-covered by the insulator.

~~According to claim 20,~~ a A method of making a chip resistor having low resistance ~~comprising~~ comprises the steps of: preparing a lead frame integrally formed with a plurality of lead bars for making resistor elements, the preparation using a metal plate; forming a pure metal plating layer on a surface of the resistor element in each bar of the lead frame; forming an insulator for covering at least a lower surface of the resistor element in each bar of the lead frame except for the ends of the lower surface; and cutting off the resistor element in each lead bar from the lead frame before metal plating layers serving as connection terminal electrodes of the resistor element are formed at the ends of the lower surface of the resistor element which are non-covered by the insulator, or forming metal plating layers serving as connection terminal electrodes of the resistor element in each bar at insulator-non-covering ends of the lower surface of the resistor element before the resistor element is cut off from the lead frame.

As described above, a resistor element formed of an alloy of high-resistant ~~resistance~~ metal and low-resistant resistance metal into a rectangular solid includes a surface formed with a plating layer which is made of pure metal with resistance lower than the alloy making the resistor element. Due to this arrangement, the resistance

Application Serial No. 10/517943
Amendment and Response
Office Action dated 10/05/2006

between the connection terminal electrodes is lowered by the pure metal plating layer which is formed on the alloy resistor element. Thus, the resistance between the connection terminal electrodes, which is resistance of the chip resistor, can be lowered without increasing the percentage of the low-resistant resistance metal relative to the high-resistant resistance metal in the alloy making the resistor element, and also without increasing the thickness of the resistor element. As resistance of a chip resistor with a predetermined length and width can be lowered without increasing the percentage of the low-resistant resistance metal, hence without making its purity closer to low-resistant resistance metal (base material metal), the above-described temperature coefficient of resistance is not increased. Further, as the thickness of the resistor element is not increased, the above structure reliably prevents difficulty in adjusting resistance by trimming and in bending process of the connection terminal electrodes, as well as increase in weight.

~~According to claim 2, the~~ The alloy making the resistor element has a negative temperature coefficient of resistance, whereas the pure metal plating layer has a positive temperature coefficient of resistance, so that the negative temperature coefficient of resistance of the resistor element can be canceled out by the positive temperature coefficient of resistance of the plating layer formed on the surface of the resistor element. Thus, the temperature coefficient of resistance of the chip resistor does not become negative, or even if negative, it can be close to a positive value. ~~Due to the arrangement according to claims 3 and 4, the~~ The resistance of the chip resistor can be lowered further ~~and/or~~ Due to the arrangement according to claim 5, the resistance of the chip resistor can be adjusted as required. Further, the arrangements ~~according to claims 6 and 7 disclosed herein~~ facilitate forming process of connection terminal electrodes at ends of the resistor element, and soldering process of the connection terminal electrodes on a printed circuit board by the plating layer formed on the surfaces of the connection terminal electrodes. The plating layer formed on the surfaces of the connection terminal electrodes can also serve to further lower resistance of the chip resistor element. ~~Further, according to claims 8 and 9, The metal plates for serving that may serve~~ as connection terminal electrodes are fixed to ends of the lower surface of the resistor element, and an

Application Serial No. 10/517943
Amendment and Response
Office Action dated 10/05/2006

insulator covers a portion between the connection terminal electrodes on the lower surface of the resistor element. Due to this, when the chip resistor is soldered to e.g. a printed circuit board, the insulator covering the lower surface prevents melted solder from coming into contact with the lower surface of the resistor element. Thus, the thickness of the connection terminal electrodes can be reduced, while reliably preventing change in resistance at the resistor element, thereby reducing the height of the chip resistor, as well as its weight. Further, ~~according to the methods of claim 16 or 17,~~ a plurality of chip resistors as the one described above can be made simultaneously at low production costs. ~~Further, according to claims 10 and 11, the~~ The insulator covers at least the lower surface of the resistor element at a portion other than the ends thereof, and metal layers are formed on the lower surface of the resistor element at the ends without the insulator to serve as the connection terminal electrode of the resistor element. Due to this arrangement, the connection terminal electrodes at the ends of the resistor element can be formed with a thin metal layer, thereby reducing the height of the chip resistor.

Additionally, when the chip resistor is soldered to e.g. a printed circuit board, the insulator covering the lower surface prevents melted solder from coming into contact with the lower surface of the resistor element. Thus, the thickness of the connection terminal electrodes can be reduced, while reliably preventing change in resistance at the resistor element, thereby reducing the height of the chip resistor, as well as its weight.

~~According to claims 12 and 13, each~~ Each of the metal layers formed at the ends of the lower surface has a thickness equal to or larger than the insulator covering the lower surface of the resistor element. Due to this arrangement, when the chip resistor is soldered to e.g. a printed circuit board, the metal layers are nearly or completely prevented from lifting up from the printed circuit board, thereby improving reliability and firmness of the soldering. Further, the methods ~~according to claims 18, 19 and 20~~ certain steps of the methods disclosed herein do not need fixing process of two metal plates and process for partly cutting one of the metal plates, thereby remarkably reducing production costs.

~~Further, according to claims 14, 15, and 19, the~~ The insulator covers the upper surface and side surfaces of the resistor element. Due to this arrangement, the insulator

Application Serial No. 10/517943
Amendment and Response
Office Action dated 10/05/2006

reliably prevents melted solder from coming into contact with the upper surface and/or the side surfaces of the resistor element, thereby reliably reducing change in resistance. Barrel-plating may be employed to form the metal layer, which facilitates the plating process, thereby reducing the production cost further.

~~According to the method of claim 20, a~~ A plurality of chip resistors are ~~simultaneously made~~ may be made simultaneously by using a single lead frame, which contributes to further reduction in production cost.